

## Natural and Cultural Resources

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*The Brookhaven National Laboratory Natural Resource Management Program is designed to protect and manage flora and fauna and the ecosystems in which they exist. The Laboratory's natural resource management strategy is based on understanding the site's resources and maintaining compliance with applicable regulations. The goals of the program include protecting and monitoring the ecosystem, conducting research, and communicating with personnel and the public on ecological issues. BNL focuses on protecting both Federal and New York State threatened and endangered species on site, as well as continuing the Laboratory's leadership role within the greater Long Island Central Pine Barrens ecosystem. Monitoring to determine whether current or historical activities are affecting natural resources is also part of the program. In 2016, deer and vegetation sampling results were consistent with previous years.*

*The overriding goal of the Cultural Resource Management Program is to ensure that proper stewardship of BNL historic resources is established and maintained. Additional goals of the program include maintaining compliance with various historic preservation and archeological laws and regulations, and ensuring the availability of identified resources to personnel and the public for research and interpretation.*

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### 6.1 NATURAL RESOURCE MANAGEMENT PROGRAM

The Natural Resource Management Program at BNL promotes stewardship of the natural resources found at the Laboratory, and integrates natural resource management and protection with BNL's scientific mission. The Natural Resource Management Plan (NRMP) describes the program strategy, elements, and planned activities for managing the various natural resources found on site. The NRMP is updated every five years with the most recent update being completed in 2016 (BNL 2016).

#### 6.1.1 Identification and Mapping

An understanding of an environmental baseline is the foundation of natural resource management planning. BNL uses digital global positioning systems (GPS) and geographic information systems (GIS) to clearly relate various "layers" of geographic information (e.g., vegetation types, soil condition, habitat, forest

health, etc.). This is done to gain insight into interrelationships between the biotic systems and physical conditions at the Laboratory.

In 2014, the southern pine beetle (SPB) was discovered at a number of locations on Long Island, including at BNL. The SPB is a native forest pest that rapidly colonizes and spreads through dense stands of pitch pines. The Laboratory has been working with the New York State Department of Environmental Conservation (NYSDEC) and the U.S. Forest Service to map and track infestations on the Laboratory site. The efforts combine aerial surveys along with ground truthing surveys and mapping.

The results of this effort are maintained within the GIS in order to track impacts to the forest.

Work associated with tracking impacts from the construction of the Long Island Solar Farm (LISF) at BNL continue to be entered into the GIS as a tool to assist analysis of changes to wildlife populations and vegetation. In 2016, natural resource personnel and

**Table 6-1. New York State Threatened, Endangered, Exploitably Vulnerable, and Species of Special Concern at BNL.**

Common Name	Scientific Name	State Status	BNL Status
<b>Insects</b>			
Black-bordered lemon moth	<i>Marimatha nigrofimbria</i>	SGCN	Confirmed
Comet damer	<i>Anax longipes</i>	SGCN	Confirmed
Frosted elfin	<i>Callophrys iris</i>	T	Likely
Little bluet	<i>Enallagma minusculum</i>	T	Likely
Mottled duskywing	<i>Erynnis martialis</i>	SC	Likely
New England bluet	<i>Enallagma laterale</i>	SGCN	Likely
Persius duskywing	<i>Erynnis persius persius</i>	E	Likely
Pine Barrens bluet	<i>Enallagma recurvatum</i>	T	Confirmed
Pine barrens zanclognatha	<i>Zanclognatha martha</i>	SGCN	Confirmed
Scarlet bluet	<i>Enallagma pictum</i>	T	Likely
<b>Fish</b>			
Banded sunfish	<i>Enneacanthus obesus</i>	T	Confirmed
Swamp darter	<i>Etheostoma fusiforme</i>	T	Confirmed
<b>Amphibians</b>			
Eastern spadefoot toad	<i>Scaphiopus holbrookii</i>	SC	Confirmed
Eastern tiger salamander	<i>Ambystoma tigrinum tigrinum</i>	E	Confirmed
Four-toed salamander	<i>Hemidactylium scutatum</i>	SGCN	Confirmed
Fowler's toad	<i>Bufo fowleri</i>	SGCN	Confirmed
Marbled salamander	<i>Ambystoma opacum</i>	SC	Confirmed
<b>Reptiles</b>			
Eastern box turtle	<i>Terrapene carolina</i>	SC	Confirmed
Eastern hognose snake	<i>Heterodon platyrhinos</i>	SC	Confirmed
Eastern ribbon snake	<i>Thamnophis sauritus</i>	SGCN	Confirmed
Northern black racer	<i>Coluber constrictor</i>	SGCN	Confirmed
Snapping turtle	<i>Chelydra serpentina</i>	SGCN	Confirmed
Spotted turtle	<i>Clemmys guttata</i>	SC	Confirmed
Stinkpot turtle	<i>Sternotherus odoratus</i>	SGCN	Confirmed
Worm snake	<i>Carphophis amoenus</i>	SC	Confirmed
<b>Birds (nesting, transient, or potentially present)</b>			
Black-billed cuckoo	<i>Coccyzus erythrophthalmus</i>	SGCN	Confirmed
Blue-winged warbler	<i>Vermivora pinus</i>	SGCN	Confirmed
Brown thrasher	<i>Toxostoma rufum</i>	SGCN	Confirmed
Cooper's hawk	<i>Accipiter cooperii</i>	SC	Confirmed
Glossy ibis	<i>Plegadis falcinellus</i>	SGCN	Confirmed
Grasshopper sparrow	<i>Ammodramus savannarum</i>	SC	Confirmed
Great egret	<i>Ardea alba</i>	SGCN	Confirmed
Horned lark	<i>Eremophila alpestris</i>	SC	Confirmed
Northern bobwhite	<i>Colinus virginianus</i>	SGCN	Confirmed
Northern harrier	<i>Circus cyaneus</i>	T	Confirmed
Osprey	<i>Pandion haliaetus</i>	SC	Confirmed
Prairie warbler	<i>Dendroica discolor</i>	SGCN	Confirmed
Red-headed woodpecker	<i>Melanerpes erythrocephalus</i>	SC	Confirmed
Scarlet tanager	<i>Piranga olivacea</i>	SGCN	Confirmed
Sharp-shinned hawk	<i>Accipiter striatus</i>	SC	Confirmed
Whip-poor-will	<i>Caprimulgus vociferus</i>	SC	Confirmed
Wood thrush	<i>Hylocichla mustelina</i>	SGCN	Confirmed
<b>Mammals</b>			
Northern long-eared bat *	<i>Myotis septentrionalis</i>	FT	Confirmed
<b>Plants</b>			
Bayberry	<i>Myrica pensylvanica</i>	V	Confirmed
Bracken fern	<i>Pteridium alquilinum var. pseudocaudatum</i>	E	Possible

(continued on next page)

interns continued to look at use of the LISF site by wildlife; use of fence openings by wildlife; changes in bird use; and changes in vegetation.

A wide variety of vegetation, birds, reptiles, amphibians, and mammals inhabit the site. Through implementation of the NRMP, endangered, threatened, and species of special concern have been identified as having been resident at BNL during the past 30 years or are expected to be present on site (see Table 6-1). The only New York State endangered species confirmed as currently inhabiting Laboratory property is the eastern tiger salamander (*Ambystoma t. tigrinum*). Six other New York State endangered species have been identified at BNL in the past or are possibly present including: the Persius duskywing butterfly (*Erynnis p. persius*), crested fringed orchid (*Plantathera cristata*), Engelmann spikerush (*Eleocharis engelmannii*), fireweed (*Erectites heiracifolia var. megalocarpa*), dwarf huckleberry (*Gaylussacia bigeloviana*), and whorled loosestrife (*Lysimachia quadrifoli*).

Seven New York State threatened species have been positively identified on site and three other species are considered likely to be present. Threatened species include two fish (banded sunfish [*Enneacanthus obesus*] and swamp darter [*Etheostoma fusiforme*]) and three plants (stiff-leaved goldenrod [*Oligoneuron rigida*], stargrass [*Aletris farinose*], and eastern showy aster [*Eurybia spectabilis*]). The northern harrier (*Circus cyaneus*) is periodically seen in

**Table 6-1. New York State Threatened, Endangered, Exploitably Vulnerable, and Species of Special Concern at BNL (concluded).**

Common Name	Scientific Name	State Status	BNL Status
Butterfly weed	<i>Asclepias tuberosa</i> ssp. <i>interior</i>	V	Confirmed
Cinnamon fern	<i>Osmunda cinnamomea</i>	V	Confirmed
Clayton's fern	<i>Osmunda claytoniana</i>	V	Confirmed
Crested fringed orchid	<i>Plantanthera cristata</i>	E	Likely
Dwarf huckleberry	<i>Gaylussacia bigeloviana</i>	E	Confirmed
Eastern showy aster	<i>Eurybia spectabilis</i>	T	Confirmed
Engelman spikerush	<i>Eleocharis engelmannii</i>	E	Confirmed
Fireweed	<i>Erectites heiracifolia</i> var. <i>megalocarpa</i>	E	Possible
Flowering dogwood	<i>Cornus florida</i>	V	Confirmed
Green fringed orchid	<i>Platanthera lacera</i>	V	Confirmed
Ground pine	<i>Dendrolycopodium obscurum</i>	V	Confirmed
Long-beaked bald-rush	<i>Rhynchospora scirpoides</i>	R	Confirmed
Marginal wood fern	<i>Dryopteris marginalis</i>	V	Confirmed
Marsh fern	<i>Thelypteris palustris</i> var. <i>pubescens</i>	V	Confirmed
Narrow-leaved bush clover	<i>Lespedeza augustifolia</i>	R	Confirmed
New York fern	<i>Thelypteris novaboracensis</i>	V	Confirmed
Pink lady's slipper	<i>Cypripedium acaule</i>	V	Confirmed
Possum haw	<i>Viburnum nudum</i> var. <i>nudum</i>	E	Possible
Prostate knotweed	<i>Polygonum aviculare</i> ssp. <i>buxiforme</i>	E	Possible
Round-leaved sundew	<i>Drosera rotundifolia</i> var. <i>rotundifolia</i>	V	Confirmed
Royal fern	<i>Osmunda regalis</i>	V	Confirmed
Sheep laurel	<i>Kalmia angustifolia</i>	V	Confirmed
Small-flowered false foxglove	<i>Agalinis paupercula</i>	R	Confirmed
Spotted wintergreen	<i>Chimaphila maculata</i>	V	Confirmed
Stargrass	<i>Aletris farinosa</i>	T	Confirmed
Stiff-leaved goldenrod	<i>Oligoneuron rigida</i>	T	Confirmed
Swamp azalea	<i>Rhododendron viscosum</i>	V	Confirmed
Virginia chain-fern	<i>Woodwardia virginica</i>	V	Confirmed
Whorled loosestrife	<i>Lysimachia quadrifolia</i>	E	Confirmed
Wild lupine	<i>Lupinus perennis</i>	R	Confirmed
Winterberry	<i>Ilex verticillata</i>	V	Confirmed

Notes:  
 Table information based on 6 NYCRR Part 182, NYCRR Part 193, and BNL survey data.  
 \* Species added in 2015  
 E = endangered  
 F = federally threatened  
 R = rare  
 SC = species of special concern  
 SGCN = species of greatest conservation need  
 T = threatened  
 V = exploitably vulnerable

the fall. Insects listed as threatened include a damselfly, the Pine Barrens bluet (*Enallagma recurvatum*), which was confirmed at one of the many coastal plain ponds located on site. Two other damselflies, the little bluet (*Enallagma minisculum*) and the scarlet bluet (*Enallagma pictum*) are likely to be present at one or more of the ponds on site. The frosted elfin

(*Callophrys irus*), a butterfly, has been historically present on site due to its preferred habitat and host plant, wild lupine (*Lupinus perennis*).

A number of other species that are listed as rare, of special concern, or exploitably vulnerable by New York State either currently inhabit the site, visit during migration, or have been identified historically.

BNL historically has had no federally threatened or endangered species present on site. On October 2, 2013, the U.S. Fish & Wildlife Service (FWS) published a notice in the Federal Register that the northern long-eared bat (*Myotis septentrionalis*) be recommended for listing as an Endangered Species under the Federal Endangered Species Act (ESA). The comment period was extended two times with a final determination and publishing of the northern long-eared bat as a threatened species on April 2, 2015, with an effective date of May 4, 2015. A draft rule under section 4(d) of the ESA was published concurrent to the determination of threatened status and provided guidance on management requirements. The draft 4(d) rule was finalized in early 2016. The northern long-eared bat is known to be present at BNL, having been identified as the first case of white-nosed syndrome found on Long Island in 2011. The bat has been added to the Laboratory's list of protected species.

**6.1.2 Habitat Protection and Enhancement**

BNL has administrative processes in place to protect on-site habitats and natural resources. Activities to eliminate or minimize negative

effects on endangered, threatened, or sensitive species are either incorporated into Laboratory procedures or into specific program or project plans. Human access to critical habitats, when necessary, is limited, and habitats are enhanced to improve survival or increase populations. Routine activities, such as road maintenance, are not performed until the planned activities have been evaluated and determined to be unlikely to affect habitat.

#### 6.1.2.1 Salamander Protection Efforts

Many safeguards are in place to protect eastern tiger salamander breeding areas. BNL staff must review any project planned near eastern tiger salamander habitats, and every effort is made to minimize impacts. A map of the breeding areas is reviewed when new projects are proposed. The map is updated as new information concerning the salamanders is generated through research and monitoring. The current map incorporates buffer areas around tiger salamander habitats of 1,000 feet based on guidance from NYSDEC. Other efforts to protect this state-endangered species include determining when adult salamanders are migrating toward breeding locations, when metamorphosis has been completed, and when juveniles are migrating after metamorphosis. During these times, construction and maintenance activities near their habitats are postponed or closely monitored.

Water quality testing is conducted as part of the routine monitoring of recharge basins, as discussed in Chapter 5. In cooperation with NYSDEC, habitat surveys have been routinely conducted since 1999. Biologists conducting egg mass and larval surveys have confirmed that 26 on-site ponds are used by eastern tiger salamanders. In 2016, egg mass surveys confirmed the presence of salamanders in 8 of the 26 ponds. Whenever possible, ponds with documented egg masses from the spring surveys are revisited in June and July to check for the presence of larval salamanders. Long Island's drought continued in 2016, with virtually all on-site ponds drying after winter rains concluded.

#### 6.1.2.2 Banded Sunfish

Banded sunfish protection efforts include observing whether adequate water is present within areas currently identified as sunfish habitat, ensuring that vegetation in their habitat is not disturbed, and evaluating all activities taking place in ponds and the Peconic River on site for potential impacts on these habitats. Population estimates are periodically conducted within these waters to determine their current health. During the last population survey in 2011, approximately 6,400 banded sunfish were counted. In 2015, the only known pond with banded sunfish was nearly dry due to drought conditions. A very small depression remained wet throughout the year and may have harbored fish. However, this area was completely dry during 2016 due to continued drought conditions. Regionally, NYSDEC determined that only a few populations of banded sunfish survived the drought and will evaluate the need for restoration efforts.

#### 6.1.2.3 Migratory Birds

A total of 216 species of birds have been identified at BNL since 1948; at least 85 species are known to nest on site. Some of these nesting birds have shown declines in their populations nationwide over the past 30 years. The Laboratory conducts routine monitoring of songbirds along seven permanent bird survey routes in various habitats on site.

In 2016, monthly surveys were conducted starting at the end of April and extending through the end of August. These surveys identified 77 songbird species, compared to the 84 species identified in 2015 and 70 species in 2014. A total of 131 bird species have been identified in surveys in the past 16 years; 59 of these species were present in each of the past 16 years. Variations in the number and species identified during each survey may reflect the time of observation, variations in weather patterns between years, and possible changes in the environment.

The three most diverse transects pass near on-site wetlands near the LISF and the Peconic River. The four transects passing through the various forest types on site (white pine, moist

pine barrens, and dry pine barrens) showed a less diverse bird community. Bird survey data are stored in an electronic database for future reference and study. No data on the effects of a large, utility-scale solar array such as the LISF are known within scientific literature. To assess the effects of the solar farm on local bird populations, the collection of migratory bird data in both the Biology Field and Solar Farm transects is important. The solar farm vegetation and the way it is managed may play a key role as habitat for migratory birds. One species, the indigo bunting (*Passerina cyanea*), was absent along the Biology Field transect in 2011, but was heard along the Solar Farm transect in 2012, returned to the Biology Field transect in 2013, and has been present on both transects since 2014. This temporary absence is thought to be due to disturbance from construction activities while building the solar farm.

The eastern bluebird (*Sialia sialis*) has been identified as a declining species of migratory birds in North America. This is due to loss of habitat and nest site competition from European starlings (*Sturnus vulgaris*) and house sparrows (*Passer domesticus*). BNL's NRMP includes habitat enhancement for the eastern bluebird. Since 2000, the Laboratory has installed more than 60 nest boxes around open grassland areas on site to enhance their population. Although many of these boxes were removed from service in 2010 in preparation for the construction of the LISF, the LISF created nearly 200 acres of suitable habitat for the eastern blue bird. Forty new boxes were installed around the northern most portions of the LISF in 2012 and are routinely used by bluebirds, house wrens, and tree swallows.

Migratory birds occasionally cause safety and health concerns, particularly Canada geese (*Branta canadensis*) and several species of migratory birds that occasionally nest on buildings or in construction areas on site. Approximately 11 years ago, it was determined that the resident Canada goose population at BNL reached large enough numbers that could result in health and safety issues. Beginning in 2007, under a permit from FWS, the Laboratory began managing the resident goose population by limiting the

number of eggs that could hatch. More than 20 nests were treated during 2016 to reduce the number of goslings. During the year, approximately 16 goslings were produced. By the end of 2016, the resident goose population was estimated at just over 100 birds.

#### 6.1.2.3 Northern Long-eared Bat

As discussed in Section 6.1.1, the northern long-eared bat was added to the list of federally threatened species in 2015. BNL began planning for the eventual listing and put in place actions to minimize the likelihood of impacting this species. The two most likely activities that could impact this bat are building demolition and prescribed fires. Inspections for the presence of bats are conducted in multiple ways prior to a building demolition. During spring, summer, and fall, ultrasonic acoustic monitoring is conducted around buildings to determine if there is bat activity. Regardless of the outcome of acoustic monitoring, a final internal inspection of the buildings is conducted approximately 24 hours prior to demolition to verify the absence of bats. For growing season prescribed fire, acoustic monitoring is done within the burn unit to determine if there is bat activity. If positive results are acquired, surveys of the entire unit are completed to identify potential roost trees and appropriate protections are put into place to ensure that bats are not impacted by fire. In 2016, only one building was demolished, and there was no impact to bats. In addition, there were no prescribed fires conducted due to drought conditions. No mist netting was conducted for bats in 2016.

### 6.1.3 Population Management

In addition to controlling resident Canada goose populations described above, the Laboratory also monitors and manages other populations, including species of interest, to ensure that they are sustained and to control invasive species.

#### 6.1.3.1 Wild Turkey

The forested areas of BNL provide good nesting and foraging habitat for wild turkey

(*Meleagris gallapavo*). In 2016, the on-site population was approximately 500 birds due to very successful nesting. Each year, NYSDEC manages a five-day hunting period the week of Thanksgiving and a youth-only hunt in May for several areas across Long Island, which typically results in over 100 birds taken.

#### 6.1.3.2 White-Tailed Deer

BNL consistently updates information on the resident population of white-tailed deer (*Odocoileus virginianus*). As there are no natural predators on site and hunting is not permitted at the Laboratory, there are no significant pressures on the population to migrate beyond their typical home range of approximately 1 square mile. Normally, a population density of 10 to 30 deer per square mile is considered an optimum sustainable level for a given area. This would equate to approximately 80 to 250 deer inhabiting the BNL property under optimal circumstances. This was the approximate density in 1966, when BNL reported an estimate of 267 deer on site (Dwyer 1966). The Laboratory has been conducting routine population surveys of the white-tailed deer since 2000. The fall 2016 estimate provided a range of 400-500 animals.

Deer overpopulation can affect animal and human health (e.g., animal starvation, Lyme disease from deer ticks, and collision injuries to both humans and animals), species diversity (songbird species reduction due to selective grazing and destruction of habitat by deer), and property damage (collision damage to autos and browsing damage to ornamental plantings). Deer-related collisions on site are less common than in the past, presumably due to improved vehicular speed controls, employee training, and deer management practices.

High deer populations are a regional problem, and the Laboratory is just one area on Long Island with such an issue. Multiple east end towns are now managing deer populations either through culls, hunting, or sterilization programs. In 2008, BNL began developing a deer management plan which included an option to reduce the population through culling. The planning effort included engagement of

Laboratory employees and guests in discussions concerning the need and methods for deer management. In 2012, an Environmental Assessment (EA) under the National Environmental Policy Act (NEPA) was completed and sent to New York State for comment. The Final EA was completed in the spring of 2013. Additionally, under BNL's permit for deployment of the 4-Poster tick management system issued by NYSDEC, the Laboratory is required to implement a deer management program.

In February 2015, 300 animals were taken, effectively reducing the population to approximately 530 animals. Furthermore, as many as 100 additional animals did not survive the harsh winter conditions which resulted in snow cover lasting more than 30 consecutive days. As mentioned above, estimates from fall 2016 surveys indicated that the population ranged between 400-500 animals. A second population reduction is being planned for the spring 2017, with a goal of removing another 200-250 animals, to bring the herd closer to an optimal population.

#### 6.1.4 Compliance Assurance and Potential Impact Assessment

The NEPA review process at BNL ensures that environmental impacts of a proposed action or activity are adequately evaluated and addressed. The Laboratory uses NEPA reviews when identifying potential environmental impacts associated with site activities, especially projects that may result in physical alterations to the landscape and structures. As appropriate, stakeholders such as EPA, NYSDEC, Suffolk County Department of Health Services (SCDHS), BNL's Community Advisory Council, and the Brookhaven Executive Roundtable are involved in reviewing major projects that have the potential for significant environmental impacts. Formal NEPA reviews are coordinated with the State of New York. In 2016, preparation of an EA for the continued operation of the Alternating Gradient Synchrotron Complex was completed and initial documentation for NEPA assessments were prepared for the redevelopment of BNL's Apartment Complex through a project called Discovery Park.

## 6.2 UPTON ECOLOGICAL AND RESEARCH RESERVE

The Upton Ecological and Research Reserve (Upton Reserve) consists of 530 acres located on the eastern boundary of the BNL site. The reserve has been designated as an area for the protection of sensitive habitats and a place where researchers can study local ecosystems. The Upton Reserve is home to a wide variety of flora and fauna. It contains wetlands and is largely within the core preservation area of the Long Island Central Pine Barrens. Based on information from a 1994-1995 biological survey of the Laboratory, experts believe the reserve is home to more than 200 plant species and at least 162 species of mammals, birds, fish, reptiles, and amphibians (LMS 1995).

The Upton Reserve is managed by BNL and the Foundation for Ecological Research in the Northeast (FERN). Funding is coordinated for research projects that occur within the reserve and the larger pine barrens area of Long Island. Research supported by FERN in 2016 included funding for investigative studies into the efficacy of using acoustic monitoring for pollinators.

## 6.3 MONITORING FLORA AND FAUNA

The Laboratory routinely conducts surveillance monitoring of flora and fauna to determine the effects of past and present activities on site. In addition to surveillance monitoring, routine Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)-required monitoring results associated with post-cleanup monitoring of the Peconic River is also conducted. Because soil contaminated with a radioactive isotope of cesium (Cs-137) was used in some BNL landscaping projects in the past, traces of Cs-137 attributable to past practices and world-wide fallout can be found in deer and in other animals and plants. At the cellular level, Cs-137 takes the place of potassium (K), an essential nutrient. Most radionuclide tables in this chapter also list analytical results for potassium-40 (K-40), a naturally occurring radioisotope of potassium that is commonly found in flora and fauna. Studies indicate that Cs-137

out-competes potassium when potassium salts are limited in the environment, which is typical on Long Island. Including K-40 in tables allow for a comparison with Cs-137 levels and is used, in part, to determine the accuracy of analytical results. The results of the annual sampling conducted under the flora and fauna monitoring program follow.

### 6.3.1 Deer Sampling

White-tailed deer in New York State are typically large, with males weighing, on average, approximately 150 pounds; females typically weigh approximately 100 pounds. However, white-tailed deer on Long Island tend to be much smaller, weighing an average of 80 pounds. The meat available for consumption from local deer ranges from 20 to 40 pounds per animal. Samples of meat and liver are taken from each deer, when possible, and are analyzed for Cs-137. Data are reported on a wet-weight basis, as that is the form most likely used for consumption.

Since 1996, BNL has routinely collected deer samples from on- and off-site areas. While most off-site samples are the result of car/deer accidents near the Laboratory, samples from deer taken by hunters beyond BNL boundaries or samples from car/deer accidents greater than 1 mile from BNL have also been made available for analysis. In 1998, a statistical analysis suggested that 40 deer from off site and 25 deer from on site are needed to achieve a statistically sound data set. The number obtained each year has not met this preferred level because sample availability depends on accidents between vehicles and deer and people reporting dead deer. Figure 6-1 shows the location of all deer samples taken within a 5-mile radius of the Laboratory since 2012. Most of the off-site samples are concentrated along the William Floyd Parkway on the west boundary of BNL, whereas most on-site samples are collected near the Laboratory's main entrance gate and the developed portions of the site. This distribution is due to the fact that people on their way to work see and report dead deer. Also, vehicle collisions with deer on site occur primarily early or late in the day, when

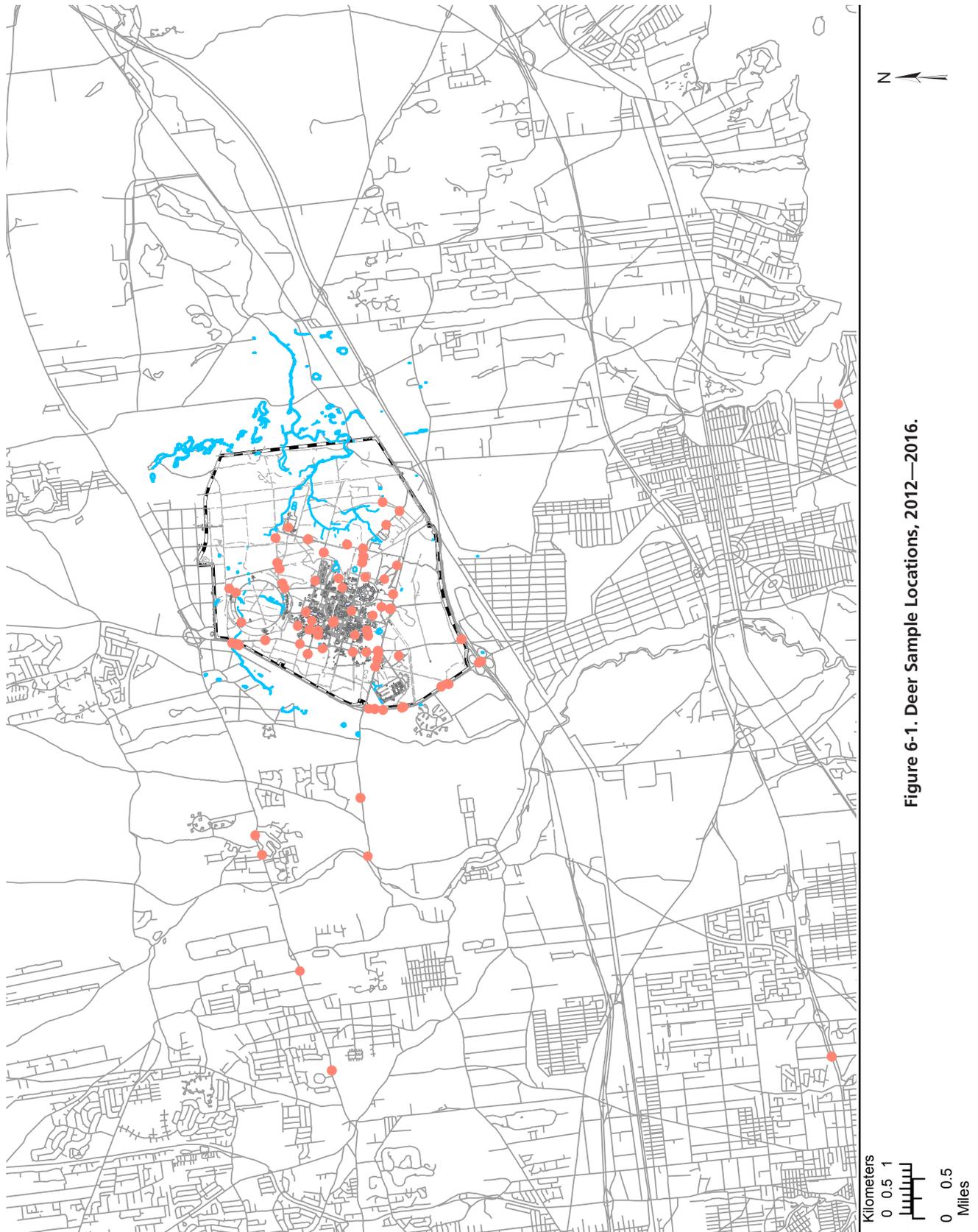


Figure 6-1. Deer Sample Locations, 2012—2016.

deer are more active and traffic to and from the front gate is greatest. Based on more than a decade of sampling, deer taken from more than 1 mile from BNL are used for comparison with populations on and near the Laboratory that could acquire Cs-137 from a BNL source.

In 2016, six deer were obtained on site, of which four were from car/deer accidents, two from off-site locations within 1 mile of the Laboratory, and two from greater than 1 mile from the BNL boundary. The analytical results of deer sampling are shown in Table 6-2.

#### 6.3.1.1 Cesium-137 in White-Tailed Deer

Based on historic and current data, white-tailed deer sampled at or near the Laboratory contain higher concentrations of Cs-137 than deer from greater than 1 mile off site. This is most likely because the deer graze on vegetation growing in soil where elevated Cs-137 levels are known to exist. Cesium-137 in soil can be transferred to above-ground plant matter via root uptake, where it then becomes available to browsing/grazing animals or is consumed directly with soil while the animal is grazing. Remediation of contaminated soil areas on site has occurred under the Laboratory's cleanup program, with all major areas of contaminated soil being remediated by September 2005.

In 2016, Cs-137 concentrations in deer meat samples were obtained from six deer on site with a range of values from 0.03 pCi/g, wet weight, to 1.69 pCi/g, wet weight, and an arithmetic average of 0.41 pCi/g, wet weight, as shown in Table 6-2. The wet weight concentration is before a sample is dried for analysis and is the form most likely to be consumed. Dry weight concentrations are typically higher than wet weight values. The highest on-site sample in 2016 (1.69 pCi/g, wet weight) was about 22 percent lower than the highest on-site sample reported in 2015 (1.92 pCi/g, wet weight) and 7 times lower than the highest level ever reported in 1996 (11.74 pCi/g, wet weight).

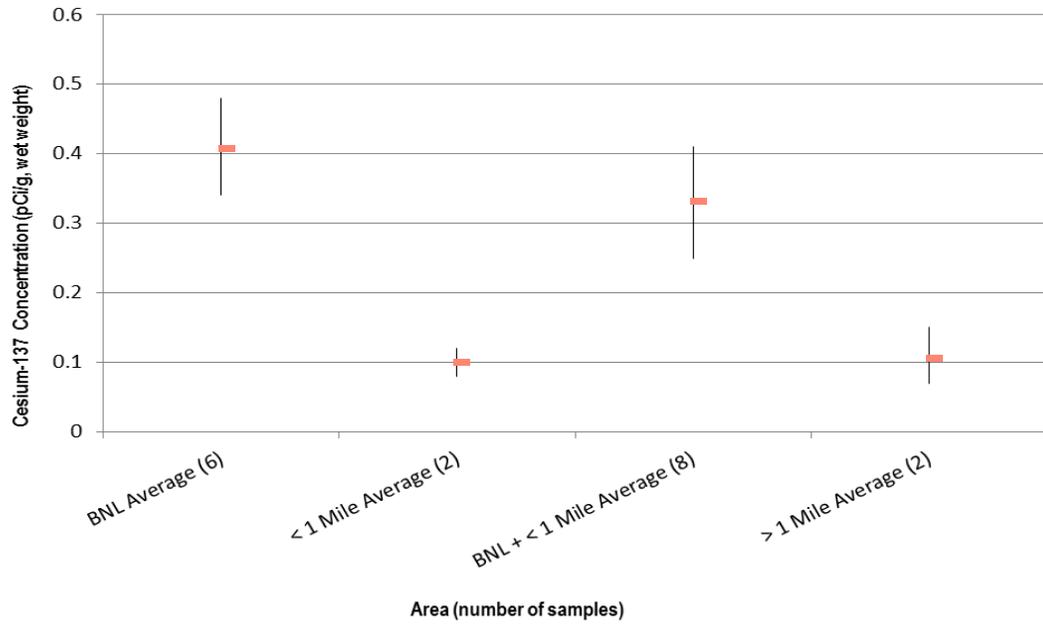
Cs-137 concentrations in off-site deer meat samples are typically separated into two groups: samples taken within 1 mile of BNL (two samples) and samples taken farther away (two samples), as shown in Table 6-2.

Concentrations in meat samples taken within 1 mile ranged from 0.04 pCi/g, wet weight, to 0.16 pCi/g, wet weight, with an arithmetic average of 0.10 pCi/g, wet weight. Because deer on site may routinely travel up to 1 mile off site, the arithmetic average for deer taken on site and within 1 mile of the Laboratory is also calculated; for 2016, this was 0.33 pCi/g, wet weight. The two deer sampled from greater than 1 mile from BNL had Cs-137 concentrations ranging between 0.08 pCi/g, wet weight, to 0.13 pCi/g, wet weight, with an arithmetic average of 0.11 pCi/g, wet weight. Figure 6-2 compares the average values of Cs-137 concentrations in meat samples collected in 2016 from four different location groupings. Beginning in 2013, the average Cs-137 content from deer taken within 1 mile of the Laboratory was lower than the on-site average, and this pattern has been consistent for the past four years. While no definitive explanation can be given to the difference from past results, it could simply be an artifact of low sample numbers and randomness in sample acquisition. Although not shown on Figure 6-2, Cs-137 concentrations in nine of the ten meat samples taken both on and off site were below 0.5 pCi/g, wet weight.

Figure 6-3 presents the 10-year trend of on-site and near off-site Cs-137 averages in deer meat. The 2016 average is approximately six times lower than the 2008 average and is slightly higher than the 2015 value of 0.28 pCi/g, wet weight, which was the lowest average seen since trending began in 2000. These sample results continue to indicate the effectiveness of cleanup actions across the Laboratory, with the trend being downward from 2007 to 2016.

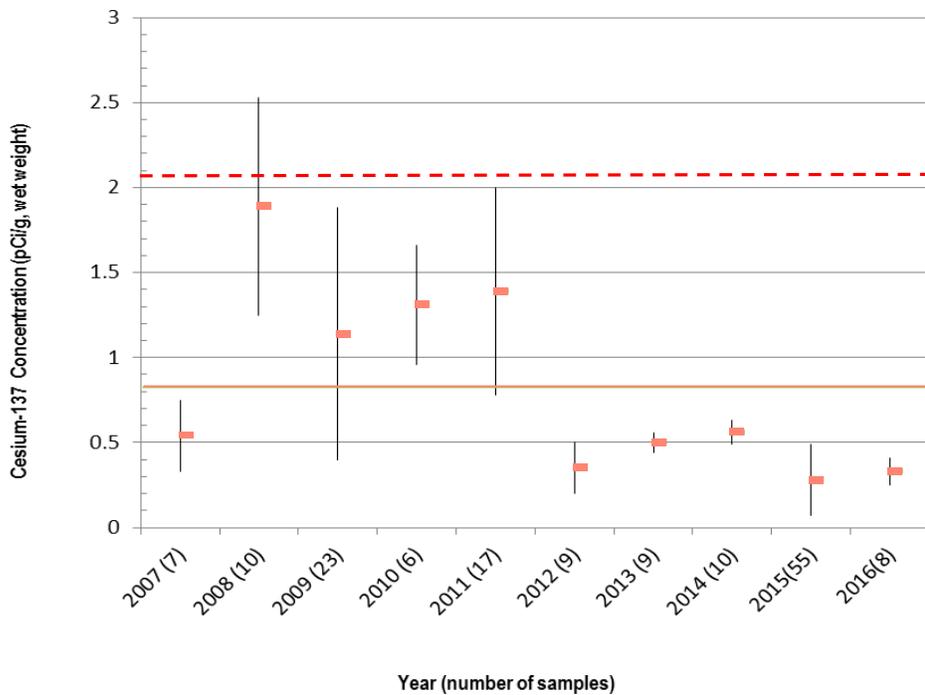
The effectiveness of the BNL soil cleanup program and the reduction of Cs-137 in deer meat was evaluated by Rispoli, et al. (2014). The average Cs-137 content was shown to be statistically lower than before cleanup. Samples taken at distances greater than 1 mile from the BNL site were shown to remain consistent before and after cleanup, while the on-site and near off-site values were shown to decline. In preparing for monitoring associated with the reduction of the deer population, the 10-year

CHAPTER 6: NATURAL AND CULTURAL RESOURCES



Notes: Averages are shown for samples collected at BNL, on site and off site within 1 mile, off site within 1 mile of BNL, and off site greater than 1 mile from BNL. Numbers in parentheses indicate the number of samples in that data set. All values are presented with a 95% confidence interval. Cs-137 = cesium-137

Figure 6-2. Comparison of Cs-137 Average Concentrations in Deer Meat, 2016.



Notes: Averages are shown for samples collected at BNL and within 1 mile. Numbers in parentheses indicate the number of samples in that data set. All values are presented with a 95% confidence interval. Cs-137 = cesium-137

Figure 6-3. Ten-Year Trend of Cs-137 Concentrations in Deer Meat.

average for on-site deer samples was calculated to be 1.0 pCi/g, wet weight, and this value was used to establish an administrative release criteria for deer meat made available for donation to the ‘Hunters-for-the-Hungry’ program.

When possible, liver samples are taken concurrently with meat samples. The liver generally accumulates Cs-137 at a lower rate than

muscle tissue. The typically lower values in liver allow the results to be used as a validity check for meat values (i.e., if liver values are higher than meat values, results can be considered questionable and should be confirmed). In liver samples collected on site in 2016, Cs-137 concentrations ranged from non-detect to 0.86 pCi/g, wet weight, with an average of

**Table 6-2. Radiological Analyses of Deer Tissue. (2016)**

Sample Location	Collection Date	Tissue	K-40 pCi/g (Wet Weight)	Cs-137 pCi/g (Wet Weight)
<b>BNL, On Site</b>				
Cornell Ave. and Rutherford Dr.	03/30/16	Flesh	3.44±0.32	0.21±0.02
		Liver	2.95±0.44	0.05±0.02
Brookhaven Ave., Bldg. 735	10/05/16	Flesh	3.12±0.32	0.03±0.01
		Liver	2.80±0.42	ND
Outer RHIC Ring Road, northeast corner	07/21/16	Flesh	3.05±0.25	0.27±0.02
		Liver	2.48±0.31	0.08±0.02
Behind Bldg. 912	09/08/16	Flesh	3.19±0.38	0.11±0.02
		Liver	2.49±0.38	0.05±0.02
Upton and Princeton Ave.	10/03/16	Flesh	3.08±0.37	0.13±0.02
		Liver	2.90±0.36	0.06±0.02
Outer RHIC Ring Road, Bldg. 1004	12/02/16	Flesh	2.74±0.28	1.69±0.06
		Liver	2.04±0.29	0.86±0.05
<b>&lt; 1 Mile from BNL</b>				
William Floyd Parkway, north of north gate, Deer 1	10/24/16	Flesh	2.86±0.28	0.04±0.01
		Liver	2.92±0.24	0.06±0.01
William Floyd Parkway, north of north gate, Deer 2	10/24/16	Flesh	3.07±0.24	0.16±0.02
		Liver	2.91±0.33	0.16±0.02
<b>&gt; 1 Mile from BNL</b>				
William Floyd Parkway, 0.5 miles south of Route 25A	09/01/16	Flesh	2.40±0.35	0.08±0.03
		Liver	2.33±0.31	0.03±0.02
Artist Lake, Middle Island	12/30/16	Flesh	2.84±0.31	0.13±0.02
		Liver	2.08±0.27	0.03±0.01
<b>Averages by Tissue</b>				
<b>Flesh Averages</b>				
All Samples (10)			2.98±0.99	0.29±0.08
BNL Average (6)			3.10±0.79	0.41±0.07
< 1 Mile Average (2)			2.97±0.37	0.10±0.02
BNL + < 1 Mile Average (8)			3.07±0.87	0.33±0.08
> 1 Mile Average (2)			2.62±0.47	0.11±0.04
<b>Liver Averages</b>				
All Samples (10)			2.59±1.08	0.14±0.08
BNL Average (6)			2.61±0.91	0.19±0.07
< 1 Mile Average (2)			2.92±0.41	0.11±0.02
BNL + < 1 Mile Average (8)			2.69±1.00	0.17±0.07
> 1 Mile Average (2)			2.21±0.41	0.03±0.02

Notes:

\* Estimated value for Cs-137 based on laboratory qualifiers.

All values are shown with a 95% confidence interval.

All averages are the arithmetic average with confidence limits using a 2 sigma (95%) propagated error.

K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.

ND = not detected

RHIC = Relativistic Heavy Ion Collider

0.19 pCi/g, wet weight. The off-site Cs-137 concentration in liver ranged from 0.06 pCi/g, wet weight, to 0.16 pCi/g, wet weight, with an arithmetic average for off-site liver samples within 1 mile of 0.11 pCi/g, wet weight. Liver samples from both deer taken greater than one mile from BNL had values of 0.03 pCi/g, wet weight; therefore the average value was also 0.03 pCi/g, wet weight.

The potential radiological dose resulting from deer meat consumption is discussed in Chapter 8. The New York State Department of Health (NYSDOH) has formally considered the potential public health risk associated with elevated Cs-137 levels in on-site deer, and determined that neither hunting restrictions nor formal health advisories are warranted (NYSDOH 1999). As mentioned prior, BNL has established an administrative release criteria of 1.0 pCi/g, wet weight, for meat donated from deer removed from the Laboratory and donated through 'Hunters-for-the-Hungry' program. No deer management actions occurred in 2016 resulting in donation of meat.

With respect to the health of on-site deer based on their exposure to radionuclides, the International Atomic Energy Agency (IAEA) has concluded that chronic dose rates of 100 millirad per day to even the most radiosensitive species in terrestrial ecosystems are unlikely to cause detrimental effects in animal populations (IAEA 1992). A deer containing a uniform distribution of Cs-137 within muscle tissue at the highest levels observed to date (11.74 pCi/g, wet weight, reported in 1996) would carry a total amount of approximately 0.2  $\mu$ Ci. That animal would receive an absorbed dose of approximately 3 millirad per day, which is only 3 percent of the IAEA threshold. The deer observed and sampled on site appear to have no health effects from the level of Cs-137 found in their tissues.

### 6.3.2 Other Animals Sampled

When other animals, such as wild turkey or Canada geese, are found dead along the roads of BNL and the immediate vicinity due to road mortality, they are tested for Cs-137. A single Canada goose was sampled in 2016 and had a non-detectable level of Cs-137.

### 6.3.3 Fish Sampling

BNL maintains an ongoing program for collecting and analyzing fish from the Peconic River and surrounding freshwater bodies. Monitoring of the river is conducted under the environmental surveillance program and the CERCLA post-cleanup program. Surveillance monitoring occurs during even-numbered years and post-cleanup monitoring occurs in odd-numbered years. With the discontinuance of discharges from the Sewage Treatment Plant (STP) to the Peconic River in September 2014, the objectives for the fish monitoring program have been changed to reflect the current intermittent presence of water in the on-site portions of the river. Fish are now only sampled when there is sufficient water to support a sufficient population of fish that can be sampled without harm to their population and that are of sufficient size for analysis. Based upon the 2016 CERCLA Five-year Review of the effectiveness of the environmental cleanup, the Laboratory intends to discontinue fish monitoring following the planned 2017 supplemental cleanup of a small area within the river. Due to lack of water and fish within the on-site portions of the Peconic River, no fish were sampled in 2016.

#### 6.3.3.1 Fish Population Assessment

The relative sizes of fish caught during annual sampling events are tracked and modifications to future sampling events are made, as necessary, to ensure long-term health of the on-site fish populations. Successful sampling of sufficiently large fish for analysis from 2008 through 2015, even with low water levels in the on-site portion of the Peconic River, indicated that populations have maintained themselves. However, the combination of no further STP discharges to the Peconic River and drought conditions have resulted in the on-site portions of the Peconic River to be totally dry, and no longer able to support fish. For fish populations to survive and flourish, water levels must be substantial enough to allow migration of fish and maintain their presence for an extended period of time to replenish populations. As mentioned above, new criteria for the collection of fish samples have been developed. These criteria will guide the environmental monitoring approach for fish in the future.

### 6.3.4 Peconic River Post-Cleanup Monitoring

Approximately 20 acres of the Peconic River were remediated in 2004 and 2005 to remove sediments containing mercury and several other contaminants. To ensure that the cleanup provided adequate protection of human health and the environment, BNL conducted five years (2006-2010) of post-cleanup monitoring of the sediment, surface water, and fish. This monitoring effort identified approximately 0.39 acres in three small areas (PR-WC-06, PR-SS-15, and sediment trap areas) with mercury concentrations greater than the cleanup goal of 2.0 mg/kg. The three areas were remediated between November 2010 and February 2011. Based upon another five years of monitoring (2011-2015), it was determined that an additional area of approximately 2,600 square feet required remediation. This area is scheduled to be remediated in the summer of 2017.

During the required CERCLA Five-Year Review process in 2016, all data and accomplishments related to the Peconic River cleanup and subsequent monitoring were summarized and reviewed by BNL and regulators (BNL 2016). The Five-Year Review recommended eliminating any monitoring beginning in 2016. Therefore, no data was collected during 2016.

### 6.3.5 Vegetation Sampling

#### 6.3.5.1 Grassy Plants and Soil

During 2016, grassy vegetation samples were collected from 12 locations around the Laboratory (Figure 6-4) and a control location at the NYSDEC hunter check station in Ridge, New York. All samples were analyzed for Cs-137 (see Table 6-3). Cs-137 content in vegetation ranged from non-detectable to 0.08 pCi/g, wet weight. Only one of the 12 samples and the control location sample had detectable levels of Cs-137. All values were consistent with historic monitoring. Monitoring results for grassy vegetation is utilized for the annual dose to biota analysis reported in Chapter 8.

Soil sampling was conducted at the same 12 locations where the grassy vegetation was collected and analyzed for Cs-137 (see Table 6-3). Cs-137 concentrations in soils ranged from non-detected to 0.88 pCi/g, dry weight. These

values were also consistent with past soil monitoring results.

## 6.4 OTHER MONITORING

### 6.4.1 Basin Sediments

A five-year cycle for the collection of recharge basin sediment samples was established in 2003. There are 11 recharge basins that receive water discharges that are permitted under the Laboratory's State Pollutant Discharge Elimination System (SPDES) permit (see Figure 5-2 for outfall locations). Basin sediments were last sampled in 2012 and results were summarized in the 2012 Site Environmental Report (BNL, 2013b). The next round of routine basin sampling will be conducted in 2017.

### 6.4.2 Mercury Monitoring of Precipitation

During 2016, precipitation samples were collected quarterly at air monitoring Stations P4 and S5 (see Figure 4-2 for station locations). The samples were analyzed for total mercury (see Table 6-4). Historically and through 2015, BNL analyzed precipitation for radiological content. However, with no emissions of significantly long-lived radionuclides from Laboratory operations, the monitoring program objectives were modified to remove testing of precipitation for radiological content beginning in 2016.

Mercury concentrations in precipitation have been measured at BNL since 2007. Analysis of mercury in precipitation is conducted to document mercury deposition that is attributable to off-site sources. This information is compared to Peconic River monitoring data and aids in understanding the distribution of mercury within the Peconic River watershed. Mercury was detected in all of the precipitation samples collected at both sampling stations. Mercury ranged from 1.84 ng/L at station S5 in January to 19.1 ng/L at station P4 in July. This range is one twelfth to three fourths of the highest value measured in precipitation, 24.6 ng/L, recorded in 2013.

## 6.5 WILDLIFE PROGRAMS

BNL sponsors a variety of educational and outreach activities involving natural resources. These programs are designed to help

Table 6-3. Radiological Analysis of Grassy Vegetation and Associated Soils.

Location/Matrix	K-40 pCi/g (Wet Weight)	Cs-137	Location/Matrix	K-40 pCi/g (Wet Weight)	Cs-137
<b>Berm of Brookhaven Linear Isotope Producer</b>			<b>No Mow, corner of Renaissance and Rutherford</b>		
Vegetation	5.86±0.82	ND	Vegetation	2.79±1.22	ND
Soil*	5.26±0.95	0.09±0.06	Soil*	7.80±0.91	0.14±0.06
<b>No Mow, south of Guest House</b>			<b>RA5 Basin bottom</b>		
Vegetation	3.92±0.070	ND	Vegetation	6.00±1.01	ND
Soil	8.19±1.35	0.40±0.08	Soil	3.06±0.54	ND
<b>No Mow, south Upton Rd.</b>			<b>Area southwest of Former Hazardous Waste Management Facility</b>		
Vegetation	8.19±0.89	ND	Vegetation	5.92±1.31	ND
Soil*	5.96±0.81	0.09±0.04	Soil*	5.30±0.77	0.16±0.06
<b>No Mow between Bldgs. 911 and 703</b>			<b>No Mow, corner of Upton and Cornell</b>		
Vegetation*	2.65±0.42	0.08±0.03	Vegetation	5.39±1.44	ND
Soil	6.60±0.82	0.32±0.06	Soil	5.48±1.13	0.22±0.07
<b>Berms of Sewage Treatment Plant sand filter beds</b>			<b>NYSDEC Game Farm (Control)</b>		
Vegetation	2.76±0.75	ND	Vegetation*	3.41±0.77	0.04±0.04
Soil	3.92±0.56	0.88±0.07	Soil	4.82±0.94	0.24±0.08
<b>Filled in Sewage Treatment Plant filter beds</b>			Notes:		
Vegetation	2.94±0.61	ND	* = estimated value for Cs-137 based on laboratory qualifiers.		
Soil	3.45±0.54	ND	All values are shown with a 95% confidence interval.		
<b>Area around HS Basin</b>			Radiological values for soils are on a 'dry weight' basis.		
Vegetation	2.46±0.71	ND	K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.		
Soil*	4.98±0.74	0.09±0.04	Cs-137 = cesium-137		
<b>Outside Long Island Solar Farm array 1, fence</b>			K-40 = potassium-40		
Vegetation	4.94±1.12	ND	ND = not detected		
Soil*	6.91±0.94	0.12±0.06	NYSDEC = New York State Department of Environmental Conservation		

participants understand the ecosystem, foster an interest in science, and to provide a meaningful experience for interns in preparation for further studies or a career. Wildlife programs are conducted at the Laboratory in collaboration with DOE, local agencies, colleges, and high schools. Ecological research is also conducted on site to update the current natural resource inventory, gain a better understanding of the ecosystem, and guide management planning.

In 2016, BNL hosted 14 student interns and two faculty members within the Natural Resources program. Two of the interns worked with a faculty member from SUNY Westbury and

two interns worked with a faculty member from Hofstra University as part of the BNL Visiting Faculty Program (VFP) and 10 interns participated in research associated with various projects including several related to the LISF. The Natural Resource program supported four interns in the spring, and one in the fall, with the remainder participating in the summer internship program.

- The VFP team from SUNY Westbury focused their research on developing new acoustic monitoring tools for identifying buzz pollinators (bumble bees). This involved the development of libraries of buzz patterns for known species.

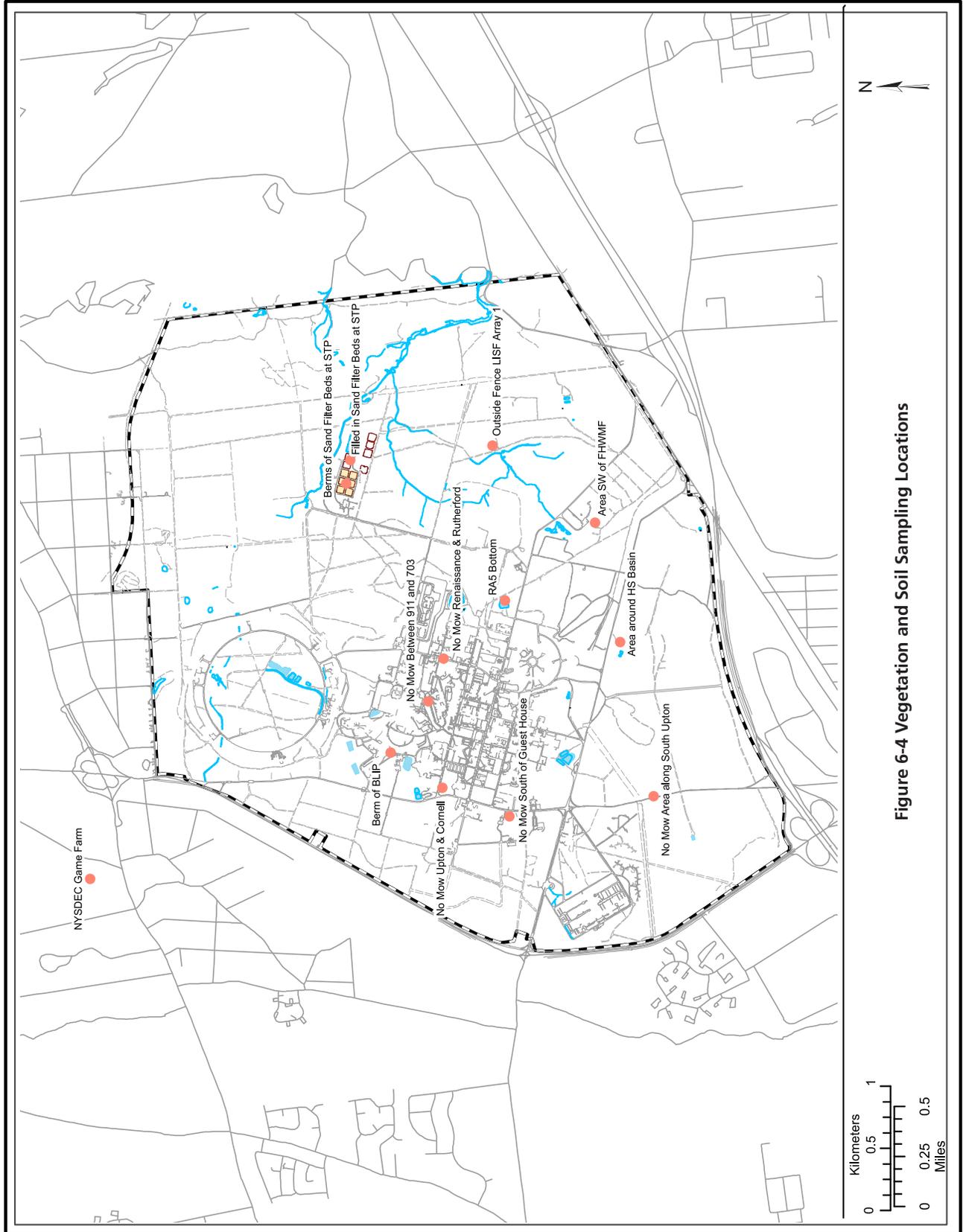


Figure 6-4 Vegetation and Soil Sampling Locations



and agencies, 47 schools, and over 2,400 students collected scientific information for analysis to be used to portray the status of the rivers and estuary systems. These events provide students hands-on experience with field techniques in catching fish, invertebrate sampling, biodiversity inventory, and water chemistry. In addition, BNL is in the 13th year of the Open Space Stewardship Program (OSSP) and worked with 30 schools and over 3,000 students in 2016. The OSSP enables students to engage in activities to solve problems within their local community through scientific discovery, conservation, and stewardship. The effort integrates outdoor research with school curricula in language arts, civics, community service, and media arts. Participation in OSSP creates an opportunity for many students to enhance their educational experiences as well as to promote the realization that a career in science and technology is accessible with the proper academic coursework and interaction with teachers and field experts who have a passion for discovery and mentorship.

The Laboratory also hosts the annual New York Wildfire & Incident Management Academy, offered by NYSDEC and the Central Pine Barrens Commission. Using the Incident Command System of wildfire management, this academy trains firefighters in the methods of wildland fire suppression, prescribed fire, and fire analysis. BNL has developed and is implementing a Wildland Fire Management Plan that includes the use of prescribed fire for fuel and forest management, and is working with NYSDEC to conduct growing season fires in northern and eastern sections of the BNL property. Although growing season prescribed fires were planned for 2016, extended drought conditions prevented their implementation.

## 6.6 CULTURAL RESOURCE ACTIVITIES

The BNL Cultural Resource Management (CRM) Program ensures that the Laboratory fully complies with numerous cultural resource regulations. The Cultural Resource Management Plan for Brookhaven National Laboratory (BNL 2013a) guides the management of all of the Laboratory's historical resources. BNL's

cultural resources include buildings and structures, World War I (WWI) earthwork features, the Camp Upton Historical Collection, scientific equipment, photo/audio/video archives, and institutional records. As various cultural resources are identified, plans for their long-term stewardship are developed and implemented. Achieving these goals will ensure that the contributions BNL and the site have made to our history and culture are documented and available for interpretation.

The Laboratory has three structures or sites that have been determined to be eligible for listing on the National Register of Historic Places: the Brookhaven Graphite Research Reactor (BGRR) complex, the High Flux Beam Reactor (HFBR) complex, and the World War I training trenches associated with Camp Upton. The trenches are examples of the few surviving World War I earthworks in the United States.

A small display on Camp Upton is continually maintained at the Laboratory's cafeteria and conference center in Berkner Hall. The display is reviewed each year for changes before the *Summer Sundays* program starts in July (see Chapter 2 for a description of this program). During *Summer Sundays* 2016, a 'History of the BNL Site' and the "Construction of Camp Upton" talks were presented to visitors. The Laboratory also made arrangements for the loan of materials associated with "Tennis for Two," which is considered to be the first video game. Materials were loaned to the New York Historical Society Museum and Library in New York City, and the Strong Museum, National Museum of Play in Rochester, New York. Items loaned to the NY Historical Society were returned to BNL.

In 2016, BNL continued planning for the redevelopment of the roughly 40 acre area of the apartment complex located just south of Princeton Avenue and the Laboratory's front gate. In preparation for the required cultural resource evaluations, BNL issued a contract with the Louis Berger Group to conduct an archeological survey of areas that had not been previously disturbed, as well as an architectural evaluation of four 1960's-era efficiency apartment buildings. The archeological survey

resulted in mostly surface finds. As there were no significant finds, the report recommended no further investigation would be needed and that the Discovery Park would not have an impact on archeological resources.

The architectural evaluation determined that the four efficiency apartment buildings were eligible for listing on the National Register of Historical Places as examples of mid-century modern architecture used for housing associated with the BNL site. The report was submitted to the NY State Historic Preservation Officer as part of a Section 106 package and is intended to be used as the mitigation for the eventual demolition of the structures. BNL must further assess options with regard to the development of the 40 acres and whether the eligible structures are beyond their useful life. All other structures and all World War II era buildings had been cleared for future demolition through the Section 106 process.

Toward the end of 2016, BNL began planning for combined celebrations for the 100th Anniversary of Camp Upton and its association with World War I, and the 70th Anniversary of the establishment of the Laboratory. BNL established one core committee for both celebrations and a subcommittee to focus on the 100th Anniversary, with activities being planned throughout the 2017 calendar year. As part of the celebration of the 100th Anniversary of World War I, the Suffolk County Historical Society requested use of several items from the Camp Upton Historical Collection. Loan agreement documents were started for the eventual loan of materials.

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